Flexible Testbed for Evaluation of Ultra-Wideband (UWB) Radios

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We have implemented a wireless LAN that is robust against fades and interference, and that has low signature, reducing the vulnerability to intercept and detection.

Project Goals

The project further explored and experimentally verified merits of UWB features and identified methods to improve performance, such as feedback loop and baseband synchronization. It also quantified and brought out the advantage of bandwidth, and demonstrated the achievable array gain.

The project allowed us to implement a flexible testbed consisting of LLNL UWB communication links, properly modified with selected features, with adjustable bandwidth, which can be configured to have single or multiple hop paths. The testbed will be used to demonstrate and evaluate UWB link capacity and robustness against fades and interference relative to that of narrowband communication.

The approach is to combine measured RF signals and interference with computer emulation of receiver processing to test options, and provide fidelity, flexibility and quick reaction. The technical challenge is to make the system usable for realistic rapid prototyping, and to control bandwidth and performance. Results will expand and validate initial UWB link and receiver models.

By the end of the project the following are to be accomplished: quantify and identify the advantages of bandwidth, and demonstrate the array gain possible with spatial processing; compare UWB to legacy narrowband links; compare LLNL's version to other UWB configurations; identify enhancements to LLNL UWB; and provide a user-friendly interface.

The flexible testbed will provide a systematic method and capability to evaluate link performance. This establishes a kernel of a library of models that will be extended as additional tasks are performed. In addition, the tool will allow a more comprehensive and realistic setting to optimize and evolve the UWB system. The effort potentially offers opportunities in the following areas: incorporation of supercomputers into the testbed; systematic optimization of the link system; and evolving hybrid simulation.

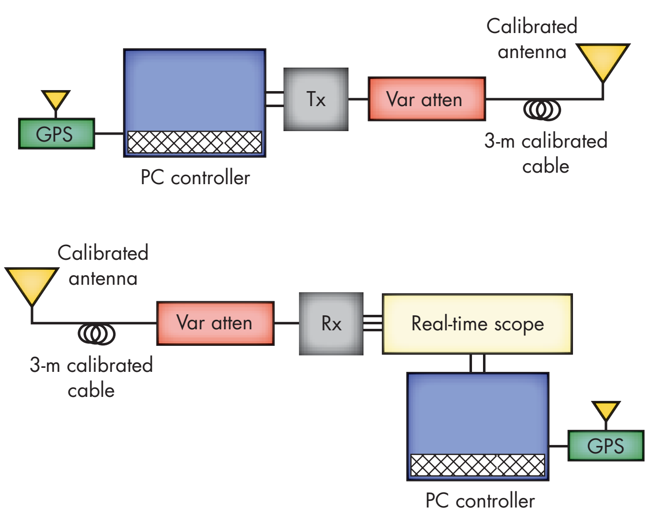

Figure 1. UWB testbed Tx and Rx block diagram.

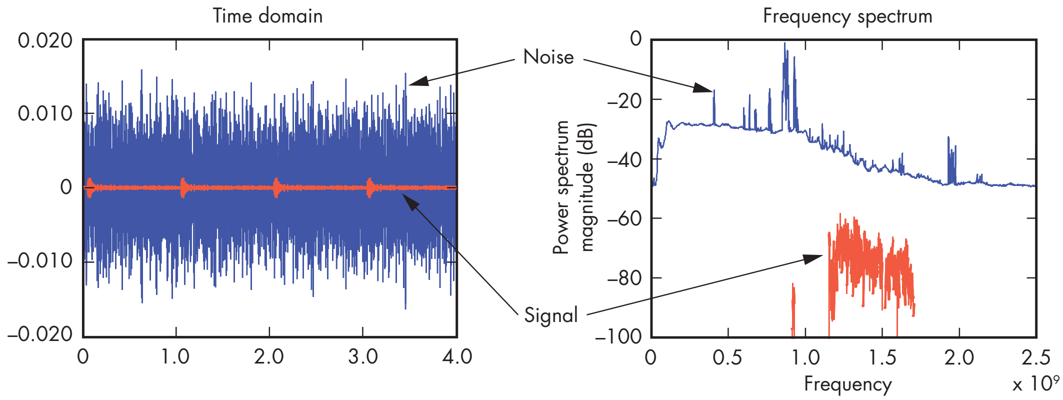

Figure 2. Illustrative results: at 250 m away, a 5-mW UWB signal was received and decoded by our novel feedback loop system.

Relevance to LLNL Mission

LLNL internal programs such as NIF, customer applications in LUGA, and homeland defense, have a need and an interest in wireless LAN that is robust against fades and interference, and that has low signature, reducing the vulnerability to intercept and detection.

FY2004 Accomplishments and Results

We have implemented an untethered testbed, intended to allow data, in the form of raw bits, files, or streaming information, to be turned into UWB bursts and transmitted at varying bit rates. These UWB RF bursts are then picked up and saved by a synchronized receiving system. The receiver uses a high-speed real-time sampling oscilloscope, taking samples of the RF at 5Gs/s and saving that information. The transmitter and receiver are not tethered to each other in any way. They rely solely on GPS timing to remain synchronized with each other. This allows the system to be deployed over great distances without the need for a cable synchronization tether connecting the two units. Basic system block diagrams of the Rx and Tx units are shown in Fig. 1.

In FY2004, we also coarsely estimated path loss and fades; collaborated with models; and introduced two IP single-pulse modulation and channel-matched signaling. Example results are shown in Fig. 2.

Related References

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4. Nekoogar, F., F. Dowla, and A. Spiridon, “A Novel Covert Transmitted-Reference Ultra-Wideband Communications,” *Military Communications Conference*, Monterey, California, October 31-November 3, 2004.
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FY2005 Proposed Work

We plan to add a GUI to the system and tabulate procedures; evaluate spatial processing (such as omni vs. directional, and two antennae vs. one); increase pulsing from 1 Mps to 20 Mps, and BW from 0.2 GHz to 2 GHz (improving confidence and statistics); correlate data with theoretical models; and evaluate and analyze stressed links and two IPs.